II.—*Natural History Notes from H. M.'s Indian Marine Survey Steamer* 'Investigator,' *Commander* Alfred Carpenter, R. N., D. S. O., *commanding.*—No. 14. *Observations on the Gestation of some Sharks and Rays.*—*By* Alfred Alcock, M. B., *Surgeon-Naturalist to the Marine Survey.*

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(With Plate I.)

The observations which I have to record were, of necessity, made so hurriedly that I can only hope them to be regarded as a gleaning in the outskirts of the field of bionomic science. But any one who, single-handed, and almost without appliances, has been called upon, at a moment's notice, to undertake the examination of large dead animal bodies in the plains of tropical India will readily realize the difficulties which hinder the exact and exhaustive dissection, under similar conditions, of huge fishes, on board ship, in the Bay of Bengal. And I trust that the drawbacks alluded to will be taken into consideration with the unfinished appearance of the work.

§ 1. *Observations on the Gestation of* Carcharias melanopterus, Zygæna blochii, *and* Carcharias dussumieri.

a. Carcharias melanopterus. A female, five feet long, was captured by Mr. W. H. W. Searle, of the 'Investigator,' on the Orissa coast, off the entrance to the Chilka Lake, on the 21st January, 1889. The abdomen was much distended; and, on opening it, the distal ends of the oviducts were found to form, on each side, an enormously dilated uterus, each occupying the whole length of the abdominal cavity on its own side.

On section, the walls of the uteri were found to be hyperæmic, rather hypertrophied, and spongy: their cavities were divided off, each into three separate longitudinal compartments: and tightly-packed in each compartment, lying head forwards, parallel with the antero-posterior axis of the mother, was a young one twelve inches long. Each young one was, further, completely enveloped in a very delicate membrane, on removal of which the placental-cord was found to be extended, in a semi-spiral curve, from a point midway between the pectoral fins of the fœtus to its maternal attachment at the hinder end of the uterus.

Each placental cord, which is about eighteen inches long, and one-sixth of an inch in diameter, is seen to divide, near the maternal attachment, into two equal branches, each of which subdivides again and again to form a compact arborescent mass, which is closely applied to a flat vascular disk on the wall of the uterus, and thus the placenta

is formed. The maternal attachment of each placental cord is separate and distinct.

At the fœtal end, the cord, having pierced the ventral wall between the pectoral fins of the fœtus, divides into two branches. The lower of these, which is the artery, can be traced into the mesentery, where, at the level of the proximal end of the large intestine, it is found to be furnished with a pouch-like gland: its connexion with the dorsal aorta could not be made out. The upper branch (venous) subdivides into two branches, which ascend in the median fissure of the liver to the portal vein.

A transverse section of the placental cord shews one artery and one vein.

A transverse section through the wall of the uterus shows an outer, thin, compact layer of muscular and connective tissue; but the greater part of the section consists of an indefinite spongy network (venous ?), with numerous large thick-walled arteries.

The red blood cells of the fœtus are $\frac{1}{1430}$ of an inch long, and $\frac{1}{2350}$ of an inch broad.

b. Zygaena blochii. On the same occasion, a female of this species, nearly five feet long, was taken. The general appearances were similar to the appearances in *Carcharias melanopterus*; but each uterus contained five fœtuses; and the placental cords, which were much more delicate, were uniformly covered, except at the extreme fœtal end, with flattened, leaf-like, bilobed or trilobed appendicula, from one-eighth to one-quarter of an inch long, each lobe being about one-eighth of an inch broad.

A transverse section of a placental cord, which includes vertical sections of the peripheral appendicula, shows, in the cord, a single artery, a large vein, and four large irregular channels; and, in each of the appendicula, a central longitudinal vessel apparently opening into one of the channels of the cord.

A single intact appendiculum, examined under a moderate power, is seen to have a thick external epithelial investment, while internally the central vessel is seen to break up into a fine ramifying and anastomosing capillary-like plexus.

A transverse section of an appendiculum, under a high power, resolves the epithelium-like investment into a gland-like aggregation of round large-nucleated cells, about ten strata deep, beneath which is the loose-meshed connective tissue of the appendiculum which supports the ramifying branches of the contained vessel.

The structure of the placenta, and the ultimate distribution of the vessels of the cord, are the same as in *Carcharias melanopterus*, but there

is no gland-like body in connexion with the artery. The red blood-cells of the fœtus are $\frac{1}{1300}$ of an inch in the major, and $\frac{1}{2860}$ of an inch in the transverse diameter.

The length of the fœtuses was about fifteen inches.

The nature of the appendicula is difficult to understand, seeing that the fœtus is connected with the mother by a large and well-developed placenta; but their richly cellular investment is evidence of some active function, either in the elaboration or purification of the blood proceeding to the fœtus. If the channels of the cord are regarded as lymphatics, the appendicula might be looked upon as forming a diffused and primitive lymphatic gland-system, their thick investment of lymphoid cells being analogous to the medulla of a mammalian lymphatic gland.

c. Carcharias dussumieri. A female, seven feet and a half long, was hooked at sea, off the west coast of Middle Andaman Island, on the 13th of April, 1889.

Immediately after death, lively movements commenced in the abdomen, which was much distended; and the abdominal cavity, on being opened, was found almost completely filled by the dilated, congested, spongy-walled uteri, as in the case of *Carcharias melanopterus* and *Zygæna blochii*. Each uterus contained five living fœtuses, each two feet long, lying head forwards in separate compartments, each with its own placenta, exactly in the manner already described. The placental cords had the usual appearance.

The young ones when removed to a tub of sea-water swam about vigorously for nearly an hour, but died eventually from hemorrhage, due to rupture of the placental cord.

The structure of the placenta, and the distribution of the vessels of the cord, were exactly similar to those of *C. melanopterus*; but no gland-like organ was found on the artery.

Unfortunately, the selected specimens, though placed in strong alcohol, putrified.

The specimens of *Carcharias melanopterus* and *Zygæna blochii*, though packed in salt, became so rotten that they fell to pieces.

§ 2. *Observations on the Gestation of* Trygon bleekeri, *and on the Uterus of* Myliobatis nieuhofii.

a. Trygon bleekeri. A female, with a disk of very large dimensions, was taken in the seine, by Mr. W. H. W. Searle, in False Point Harbour (Orissa coast), on the 15th December, 1888.

The distal end of the right oviduct was enormously dilated, and contained in its cavity a fully-developed male fœtus with a disk $11\frac{3}{4}$ inches long and $10\frac{3}{4}$ inches broad.

The striking feature was, that there was no connexion of any kind between the fœtus and the mother, and no evidence of any such previous connexion.

The mucous membrane of the uterus, however, was covered with an abundant glairy albuminous fluid, the secretion apparently of a layer of thick-set papillæ which formed its inner coat; and the inference seems irresistible that this fluid constituted the nutriment of the fœtus, and was, in short, a true uterine milk. Unfortunately, the examination of the stomach of the fœtus was delayed for twenty-four hours, when the viscera had undergone such changes that the verification of this theory was hardly possible.

On removal of the fluid, which was then found to form a nearly solid coagulum on the application of heat, the papillary layer of the mucous membrane of the uterus was found to be of a vivid scarlet.

The papillæ themselves average about half an inch in length, and are filiform in shape, and very delicate. They are so thick-set as to be in contact when not floated out in water.

Beneath them is a thick mucous layer rich in blood-vessels, and outside this is (1) an inner circular and outer longitudinal layer of muscle, and (2) a connective-tissue coat; the whole aggregating in thickness one-eighth of an inch.

The thickness and compactness of the muscular coat is in striking contrast with the loose spongy nature of the uterine walls in *Carcharias* and *Zygæna*, and appears to indicate much greater parturient effort in *Trygon*.

b. Myliobatis nieuhofii. A female, with a disk seventeen inches long and twenty-eight broad, was taken in the seine, by Mr. W. H. W. Searle, off Cocanada, on the 31st March, 1889.

The left ovary was full of large ova, and the distal end of its oviduct formed a large globular swelling, with thick, firm, muscular walls, and a uniform internal lining of broad flattened papillæ nearly half an inch long.

On the posterior surface of this uterus, and closely adherent to it, was an indistinctly lobulated gland-like organ, which, on section, was found to consist of an aggregation of tubules with blood-vessels and characteristic glomeruli, and a small amount of intertubular stroma. The tubules were lined with large-nucleated, cubical, epithelium. Unfortunately, the other relations of this kidney were missed.

A section through the uterus shows, from without inwards, (1) a compact connective-tissue investment about one-eightieth of an inch thick, with numerous large blood-vessels; (2) a layer of unstriped muscular tissue in transverse bundles; (3) a layer of similar muscular

tissue in longitudinal bundles, the united thickness of the two layers being about one-nineteenth of an inch; (4) a mucous layer of varying thickness, containing numerous blood-vessels and lymphatic (?) spaces, and crowded with lymphoid cells.

This mucous layer forms the long papillæ above mentioned, and a uniform sheet of close-set tubular glands, which resemble, for the most part, the lieberkuhnian follicles of human anatomy, covers its entire surface, both papillary and inter-papillary. These glands, at any rate near their orifices, are lined with short columnar epithelial cells, and similar cells invest the surface of the mucous membrane between the orifices of the glands.

The individual papillæ, as already stated, are about half an inch long, and are flattened. In some cases they bifurcate or trifurcate. In breadth they vary from one forty-eighth to one twenty-fourth of an inch. They are formed by a central prolongation of the mucous coat richly provided with lymphoid cells, and containing at least one blood-vessel and numerous lymphatic (?) spaces; and are invested externally by the above-described layer of tubular glands. These glands are mostly simple at the bases of the papillæ, but peripherally they frequently become racemose, and in this case the acini are lined internally with a cubical epithelium.

As to the function of this vast surface of glandular tissue, we are able to form an opinion by referring to the case of *Trygon bleekeri*. There we found a uterus exactly similar in its naked eye anatomy to the one we are discussing; and in this uterus was a large fœtus entirely separate, as far as structural connexion goes, from the mother; while the uterine papillary surface was concealed by a copious secretion of a highly albuminous, and presumably nutritive, fluid. In the absence of any vascular connexion between the fœtus and the mother, we assumed that this fluid served for the nutrition of the fœtus.

In *Myliobatis nieuhofii*, in which the uterine papillæ are less attenuated, and more amenable to manipulation, we find the whole intra-uterine mucous membrane forming a superficial gland; and I think we are justified in assuming that this gland is practically a milk-gland, the secretion of which furnishes the developing fœtus with nutriment.

In the *Zoological Record* the only allusion to uterine villi that I can find is to a paper by Trois, in the "*Atti del Instituto Veneto*" Vol. II, p. 429, "On the uterine villi of *Myliobatis noctula* and *Centrina salviani*;" but I regret that I have not been able to obtain access to this.

Explanation of Plate I.

Fig. 1. A piece of the placental cord of *Zygæna blochii*, natural size.

Fig. 2. Transverse section through the same, showing artery and vein, lymphatic (?) spaces, and three appendicula in oblique section with parts of two more in vertical section. × 16.

Fig. 3. A portion of one of the appendicula of the same, showing the ramifying vessel. × 21.

Fig. 4. Transverse section through part of one of the appendicula of the same, near its base. × 110.

Fig. 5. Transverse section through uterine wall of *Myliobatis nieuhofii*, showing fibrous and muscular coats, and mucous membrane, with the bases of three papillæ. × 21.

Fig. 6. Obliquely transverse section through part of one of the uterine papillæ of the same, showing some of the simple follicles of the mucous membrane in oblique section, and one of the racemose follicles. × 110.

III.—*On Clebsch's Transformation of the Hydrokinetic Equations.*

By Asutosh Mukhopadhyay, M. A., F. R. A. S., F. R. S. E.

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A first integral of the hydrokinetic equations of Euler may be obtained by known methods in three cases: (1) Irrotational motion; (2) Steady rotational motion; (3) General rotational motion. It is the object of this note to show how the method of applying Clebsch's transformation to the third case can be materially simplified, and incidentally the relation between the three solutions is pointed out.*

Starting, then, with the hydrokinetic equations, we remark that they may be at once reduced to the forms

$$\frac{du}{dt} - 2v\zeta + 2w\eta + \frac{dR}{dx} = 0 \qquad \ldots\ldots\ldots \quad (1)$$

$$\frac{dv}{dt} - 2w\xi + 2u\zeta + \frac{dR}{dy} = 0 \qquad \ldots\ldots\ldots \quad (2)$$

$$\frac{dw}{dt} - 2u\eta + 2v\xi + \frac{dR}{dz} = 0 \qquad \ldots\ldots\ldots \quad (3)$$

where

$$R = \int \frac{dp}{\rho} + V + \frac{1}{2} q^2$$

$$q^2 = u^2 + v^2 + w^2$$

* For the ordinary method, see Bassot's Hydrodynamics, vol. i, p. 28.

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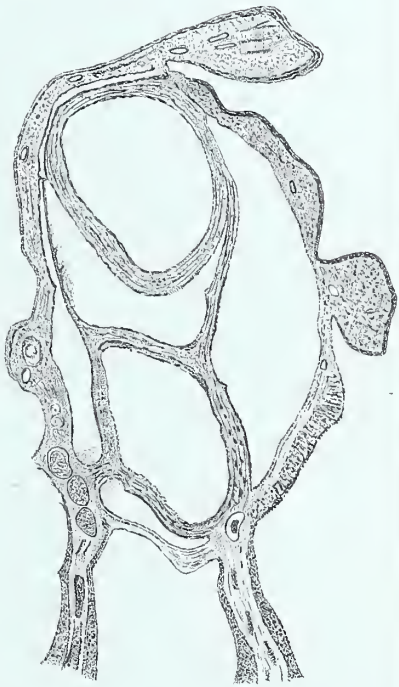

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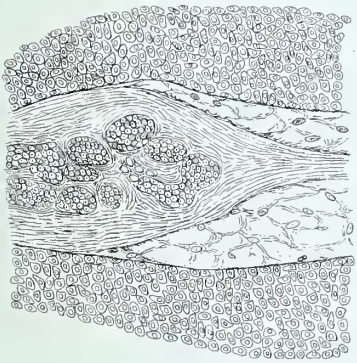

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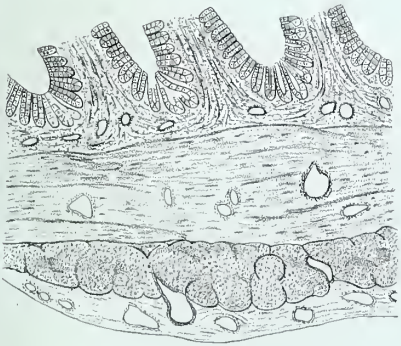

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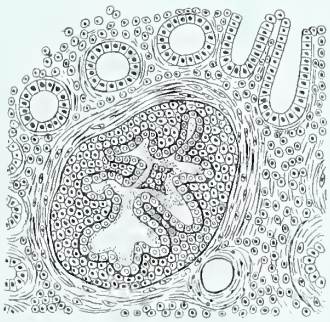

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